CUNY CREST GOES-R PROJECTS

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Huntsville, Alabama

GOES-R Projects

1. Quantitative Image Restoration (Irina Gladkova)
2. Cloud-top Relief Spatial Displacement Adjustments of GOES-R Images (Shayesteh Mahani)
3. Satellite Thunderstorm Nowcasting *(Transitioning GOES-based Nowcasting Capability into the GOES-R Era)* (Brian Vant Hull)
4. Use of Cloud Cooling Rates in Precipitation Algorithm (Brian Vant Hull – Combined with CICS)
5. Relating time scales to spatial scales of extrapolation (Brian Vant Hull – Combined with CICS)
6. Convective Storm Forecasting 1-6 Hours Prior to Initiation (Brian Vant Hull a join project with UAH/AI, CIRA, CIMSS and NOAA/NSSL)
7. Development of vegetation cover products for GOES-R ABI (Peter Romanov - a joint project with NESDIS/Bob Yu)
8. Development of Snow Depth product for GOES-R ABI (Peter Romanov - a joint project with CIMSS/Jeff Key)
9. Routine in situ measurements of reflectance anisotropy of snow and snow-free land surface for GOES-R ABI product calibration and validation (Peter Romanov and Tarenda Lakhankar)
10. Air Quality Proving Grounds (AQPG) using GOES-R Data (Barry Gross)
11. Sea ice monitoring using geostationary satellite data (Marouane Temimi and Rouzbeh Nazari)
12. Vegetation Health Index algorithm for GOES-R ABI Using Brightness Temperature (Lenny Roytman)

Quantitative Image Restoration

Reality: Detectors Break

Manufacturing Flaws
Launch Damage
Space is Harsh

MODIS AQUA
1.6 micron band:
15out of 20
Detectors Noisy or
Totally Non-
Functional

We have previously developed algorithm to restore MODIS 1.6 micron band

Research Progress:

Currently adapting MODIS 1.6 micron algorithm for ABI visible:

- Adapting to restore any ABI visible band
- Adapting to use only input available from ABI

Cloud-top Relief Spatial Displacement Adjustments of GOES-R Images

PI: Shayesteh Mahani, CREST & CE Dept. at the City College of New York (CCNY) in the City University of New York (CUNY), New York

Co-Is: Johnny Luo, William Rossow, Reza Khanbilvardi, and K. Tesfagiorgis, CREST, CCNY/CUNY, and Robert Rabin, NOAA/NSSL, UW-Madison/CIMSS

Collaborators: Andrew Heidinger and Robert Kuligowski , NESDIS-STAR,

Objectives: Estimate Cloud-Top Height (CTH) and Adjust Cloud-top Relief Spatial Displacements of GOES-R Images

Project Description:

Using stereoscopic principal to estimate cloud-top height and adjust its associated relief spatial displacement for each cloudy cell. The proposed tasks are:

Study CTH – Cloud-Top Spatial Displacements relationships for GOES-R images

Derive IR-CTH relationships using the corresponding and simultaneous IR images and stereoscopic principal, to estimate CTH;

Evaluate IR–based CTH estimates and adjusted GOES-R images

Stereoscopic Parallax Related to Cloud-Top Height

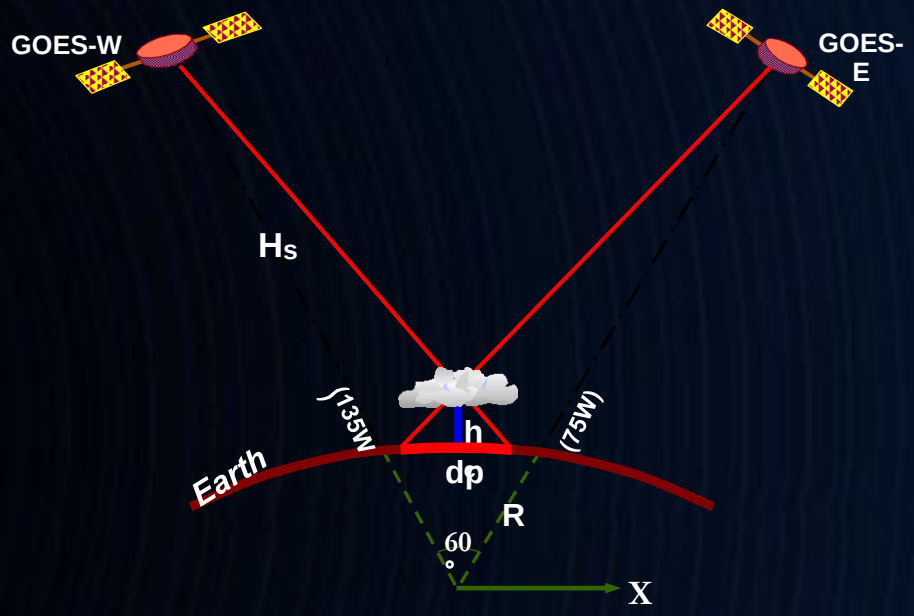
dp = the X- or Stereoscopic Parallax associated with

h_c = Cloud-Top Height, between GOES-E and -W Images

R = 6370 km (Radius of Earth)

H_s = 36000 km

For: **h_c = 10 km** ➔ **dp = 16.0 km**



Satellite Thunderstorm Nowcasting

(Transitioning GOES-based Nowcasting Capability into the GOES-R Era)

Joint Project: CREST-CUNY, NWS-MDL, NESDIS, OAR-NSSL, & CIMMS

Project Status: A funded 3 year project that ended in 2011;

Objective: To enhance the satellite-based **RDT** (Rapid Developing Thunderstorms) Model, developed by Météo-France in the framework of EUMETSAT-SAF Nowcating, that works using single channel, GOES-IR over the U.S.;

Outcome: Nowcasting cloud initiation and tracking using GOES IR, over NYC as a test bed and Oklahoma,

Research Description & Progress:

RDT model has been modified to use GOES-IR;

Cloud Life cycle has been studied;

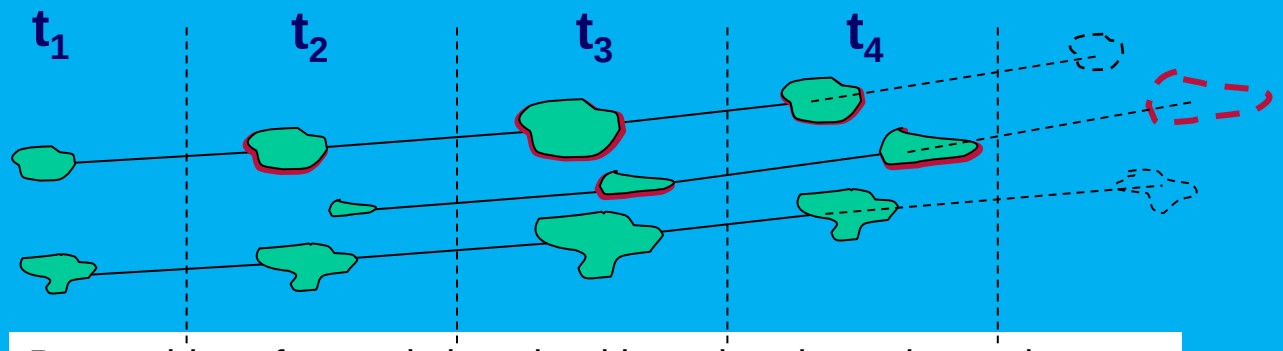
Detecting cloud cells by whether they form towers higher than a given BT threshold (6 degrees).

Tracking cells and storing all properties, such as contours, areas, growth rates, min & avg. BT, and BT gradients around the periphery;

- Lookup tables of cell lifecycles are used to determine if the cell may be convective. Growth rates and roundness of the top are important parameters.

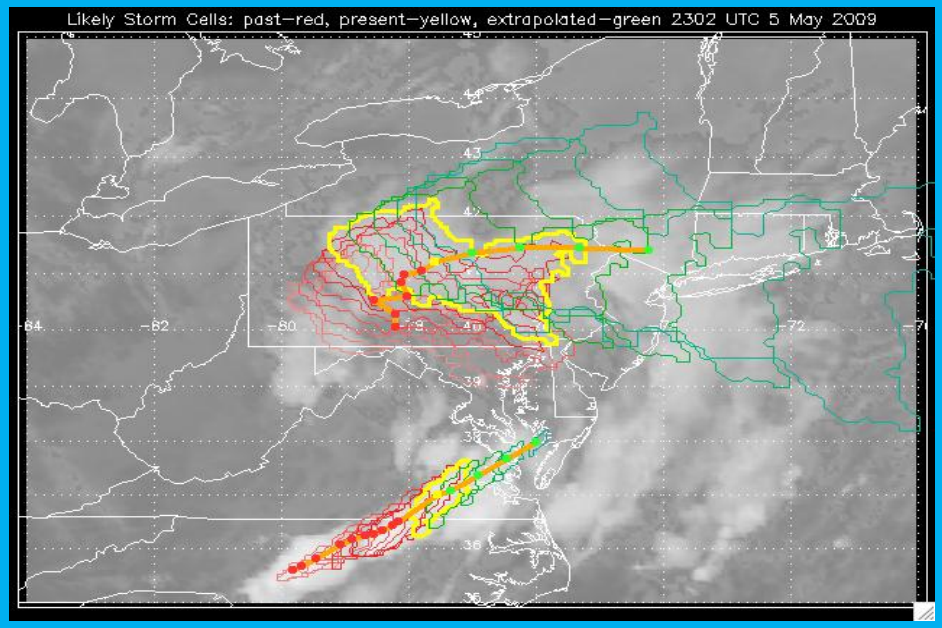
Steps in Thunderstorm Nowcasting

Cloud Tracking => Storm Detection => Extrapolation



Borrow ideas from existing algorithms that do each step best.

Applying Extrapolation



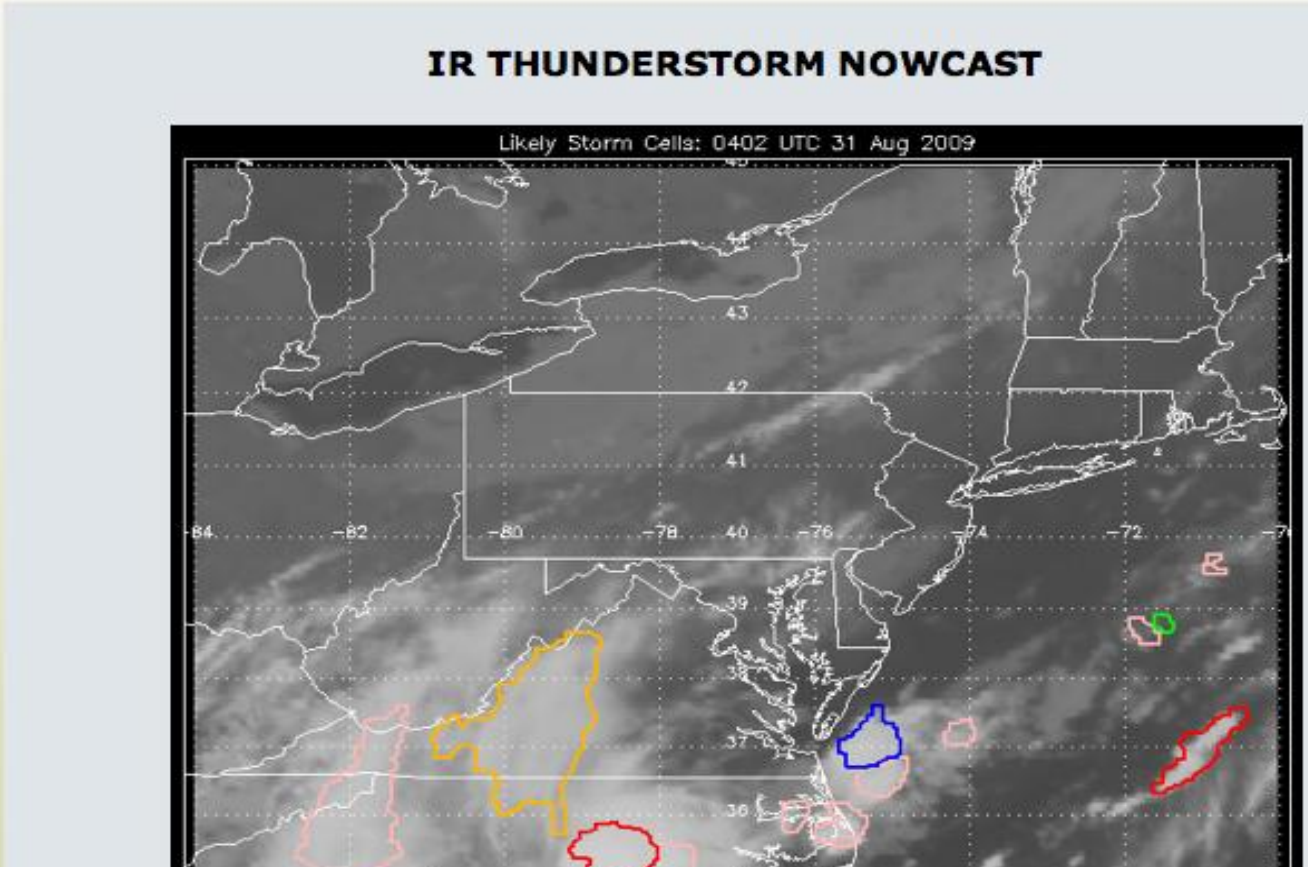
Extrapolation is based on RDT cloud lifecycles study

Red: previous
Yellow: current
Green: extrapolated

Investigation is needed to stabilize extrapolation

The RDT model in New York

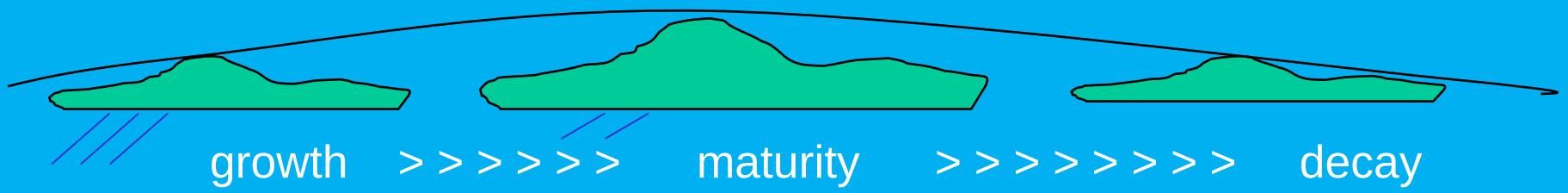
Data from direct broadcast, 15 min refresh rate; recently updated to include water vapor channels. Will be extended over Atlantic for use of aviation.



http://air.ccny.cuny.edu/

Project: Use of Cloud Cooling Rates in Precipitation Algorithm

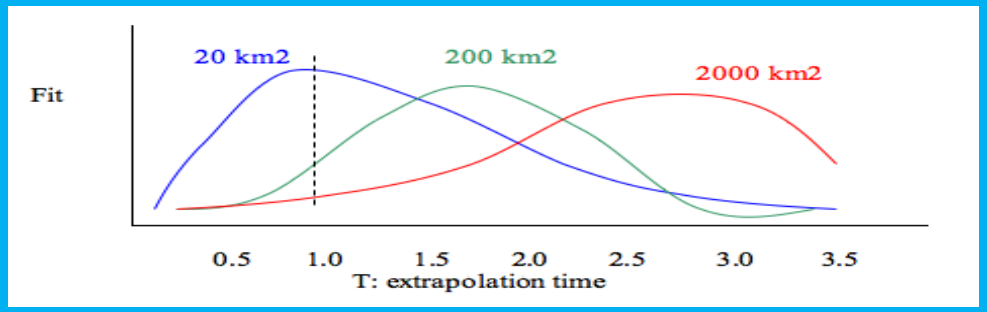
Theory: current algorithm uses radiances only, not rates of change. A growing cloud is expected to produce more precipitation than a static or decaying cloud.



Tool Implementation: Feature tracking is used to associate pixels from subsequent images, so brightness temperatures can be subtracted.

Project: Relating time scales to spatial scales of extrapolation

Theory: It is expected that larger features can be extrapolated over a larger times scale than smaller features, but is now done by guesswork.



Tool Implementation: use the same extrapolation tool for a variety of time and space scales, then devise a superposition that provides the best correlation.

Convective Storm Forecasting 1-6 Hours Prior to Initiation

John Mecikalski and John Walker, Univ. Alabama-Huntsville, Huntsville, AL
Dan Lindsey and Louie Grasso NOAA/NESDIS/STAR/RAMMB and CIRA, Fort Collins, CO
Chris Velden and Steve Wanzong, CIMSS, Madison, WI
Bob Rabin, NSSL, Norman, OK
Brian Vant-Hull, CREST, New York, NY

Project Motivation and Goal

One of the greatest difficulties in severe storm forecasting is deciding where and when storms will initially form. Current numerical models struggle with this problem and often have large errors in their 1-6-hour forecasts for convective initiation (CI). **The overall goal of this proposal is to develop a single objective system that predicts where and when storms will form 1-6 hours prior to initiation**.

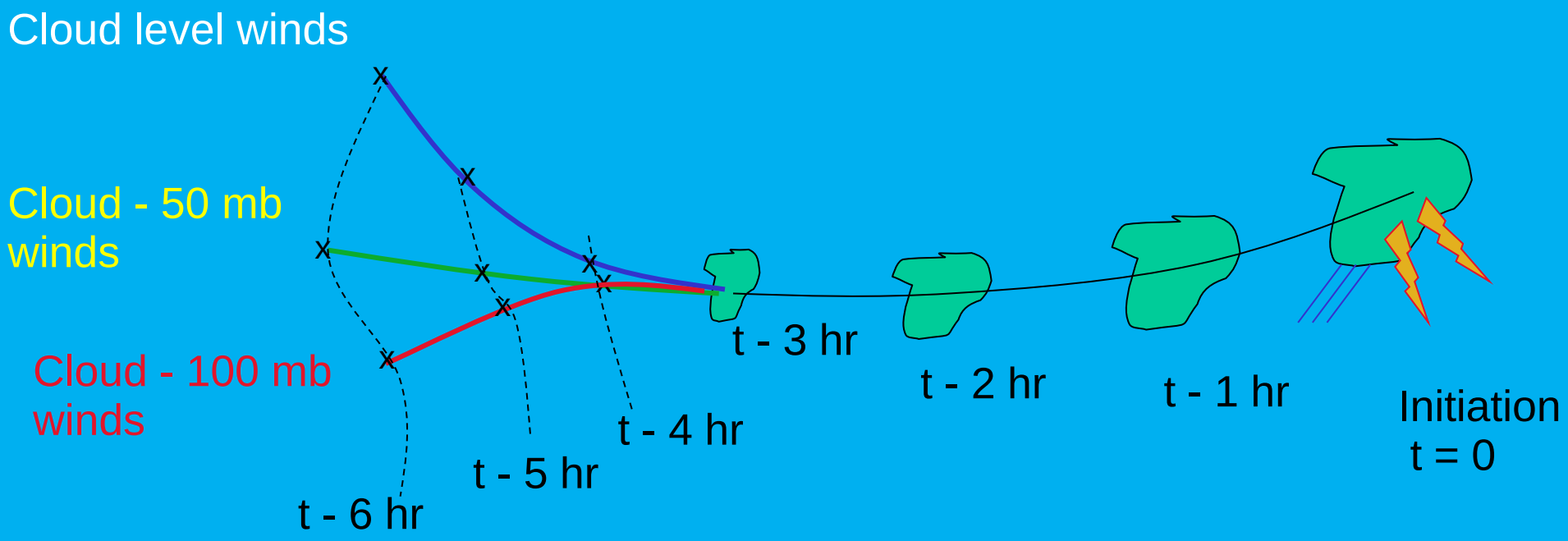
CREST Component: Create evaluation scheme for efforts put forth by other institutional teams.

Project Status: New Start, 2 year duration

Current Progress at CREST: Based on previous work, a toolkit has been developed at CREST using NSSL's WDSS-II cloud tracking algorithm that associates cloud trajectories with radar echoes, lightning, and NWP output. The data base produced by NSSL will be used to produce back trajectories from areas of convective activity to validate the convective initiation predictions.

A full description of the back trajectory scheme to be developed is described on the next page.

CREST Component: Validation



- Back trajectories in clouds followed from initiation of severe weather based on IR satellite using WDSSII segmotion algorithm.
- When clouds disappear, clear-air trajectories followed back to inititiation - 6 hours using NWP analysis winds at several different levels below the one that best matches the cloud trajectory.
- Maps created of time to initiation for each location.

Development of vegetation cover products for GOES-R ABI

Program: GOES-R ABI AWG

Product Development Lead: Peter Romanov

Land Products Team Lead: Yunyue (Bob) Yu

Project duration: 2007 -

Objective: Development of an operational algorithm and software to retrieve Normalized Difference Vegetation Index (NDVI) and Green Vegetation Fraction (GVF) from GOES-R AB

Current status and Accomplishments:

(1) NDVI and GVF algorithms have been developed, software and supporting documentation have been delivered to the project management.

(2) Algorithm and software to routinely validate VDVI and GVF products are being developed. Delivery of the first version of the algorithm is scheduled for the end of 2011.

Development of Snow Depth product for GOES-R ABI

Program: GOES-R ABI AWG

Product Development Lead: Peter Romanov

Cryosphere Team Lead: Jeff Key

Project duration: 2007 -

Objective: Development of an operational algorithm and software to retrieve Snow Depth from GOES-R AB

Current status and Accomplishments:

(1) Snow Depth algorithm has been developed, software and supporting documentation have been delivered to the project management.

(2) Algorithm and software to routinely validate the Snow Depth product are being developed. Delivery of the first version of the algorithm is scheduled for the end of 2011.

Routine in situ measurements of reflectance anisotropy of snow and snow-free land surface for GOES-R ABI product calibration and validation

Project proposal to GOES-R Calibration/Validation Field Campaign Program

PI: Peter Romanov (CREST), Co-I: Tarendra Lakhankar (CREST)

Project duration: 2011 - 2014

Objectives: To establish a ground-based system for routine measurements of the land surface spectral reflectance, develop improved models of surface reflectance anisotropy for ABI spectral bands.

Why it is important: (1) Information on the land surface reflectance anisotropy is needed in several ABI products including Snow Fraction, Albedo, Land Surface reflection, Shortwave Radiation Parameters, Floods/Standing Water. (2) Algorithms use BRDF models that are semi-empirical and are poorly validated.

Proposal current status: Decision Pending

Current AQPG efforts at CCNY

Optimize land based Multifilter Shadowband Radiometers (inexpensive – portable sensors) to develop distributed Aerosol Optical Depth (AOD) and fine mode fraction datasets to better validate GOES-R ABI

- Successful Implementation of NASA-GISS algorithms for multiple instruments demonstrates dramatic improvement over standard methods when compared with AERONET

Develop Top of Atmosphere (TOA) Radiances (i.e. Proxy Data) based on improved surface reflection and aerosol properties for the GOES-R ABI sun-view geometry

- Preliminary tests are being made in the current MODIS geometry and illustrate the need to better quantify the spectral albedo of urban surfaces

Sea ice monitoring using geostationary satellite data

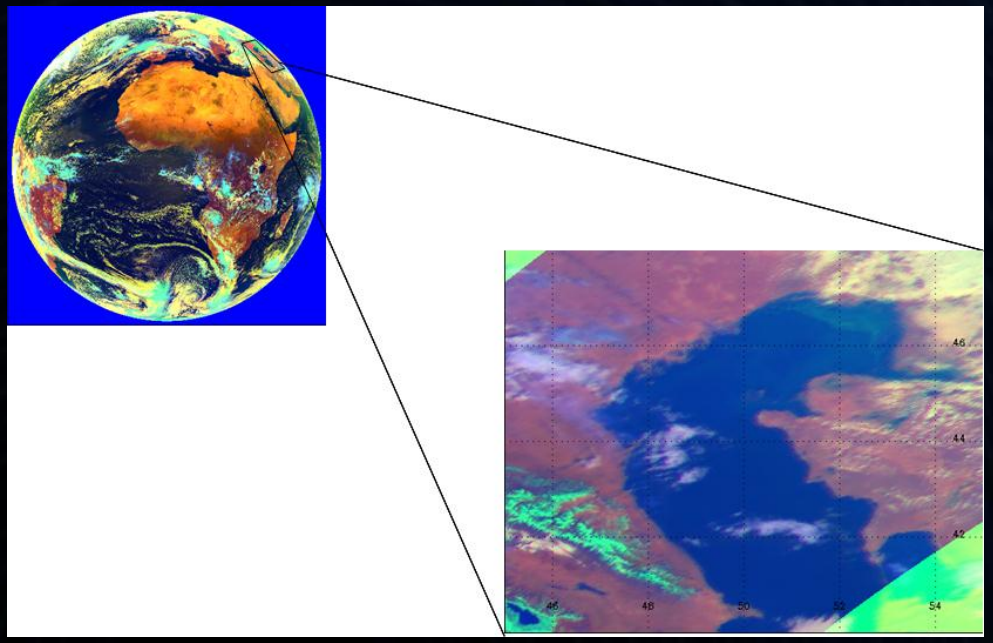
Marouane Temimi, Hosni Ghedira, Kim Smith with the collaboration of Peter Romanov and Jeff key

Achievement

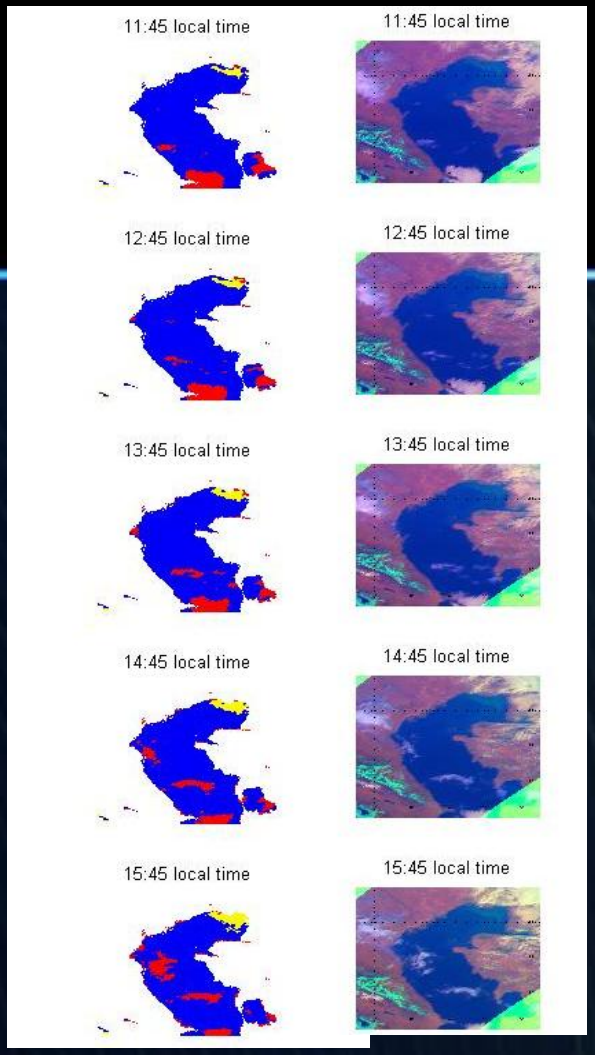
•Marouane Temimi, Peter Romanov, Hosni Ghedira, Reza Khanbilvardi and Kim Smith. An automated approach for determining sea-ice concentration for the future GOES-R ABI sensor. (2011). International Journal of remote Sensing. Vol. 32, No. 6. Page: 1575–1593. DOI: 10.1080/01431160903578820.

Development of a novel approach that accounts for the BRDF effect and the change in the geometry of observation through an adaptive neural network based BRDF model

The average percentage of cloud reduction because of the daily compositing ranged from 22% to 25%. Daily maps of ice distribution and concentration with minimal cloud coverage were produced.



MSG SEVIRI full disk false color composited image and the portion of the image over Caspian Sea re-projected to latitude-longitude grid on 23 January 2007 at 10:15 AM UTC.



Instantaneous ice maps (left column) and original MSG SEVIRI images on 23 January 2007. False color images in the right column are constructed with Ch.3 reflectance (red), HRV reflectance (green) and inverted infrared brightness temperature (blue)

Vegetation Health Index algorithm for GOES-R ABI Using Brightness Temperature

Roytman L; Nizamuddin (CUNY/CREST) and Felix Kogan (NOAA)

- **OBJECTIVE:** In this study, one year of SEVIRI data recorded at half-hour interval was collected and used, and 13 study stations were chosen from a variety of vegetation types and geo-locations from the Africa and Europe based on data from March, 2007, to February of 2008. Different criteria of estimating VHI were set to find the best method for obtaining the best quality and highest values of NDVI and BT on daily base.

- **METHODOLOGY:** Comparison of BT from AVHRR and SEVIRI. Weekly comparison of BT for different ecosystems were made

CONCLUSIONS: Experimental computations with SEVIRI data have demonstrated a good potential of a new generation of imaging instruments onboard geostationary satellites to provide more accurate routine monitoring of the vegetation state through BT. Using MSG SEVIRI as GOES-R ABI prototype, we have developed a promising BT retrieval algorithm for ABI.

It has been proven that SEVIRI BT data are better correlated with Smoothed BT.

Future work

- Adapt our current algorithm on visible bands to operate on near infra-red and infra-red ABI bands
- Investigate improvements by integrating spatial interpolation within the damaged channel with cross band interpolation
- Investigate fusing information from full disk and CONUS high resolution for restoration

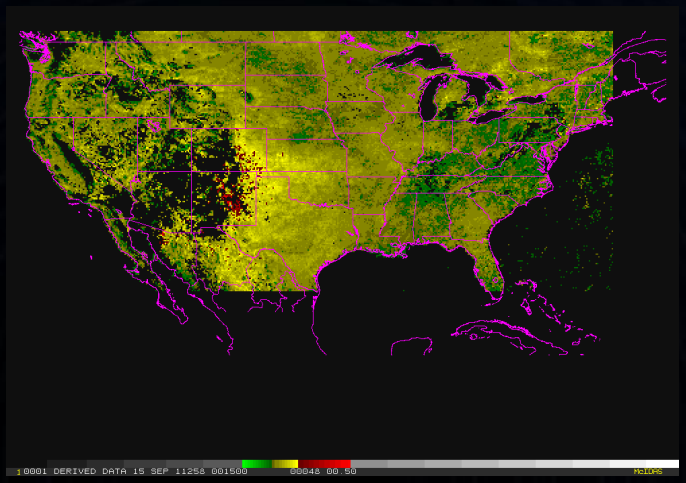
Sea ice monitoring using geostationary satellite data

Marouane Temimi, Hosni Ghedira, Kim Smith with the collaboration of Peter Romanov and Jeff key

Possible future developments

Proving Ground

Use inferred soil moisture from estimates of heating rates and thermal inertia to force/validate regional hydrological models which is critical for NWS
Currently: a join effort led by Drs Bob Rabin and Marouane Temimi prepares the ground work for such application
Lake ice product can be blended with river ice product from higher resolution sensors



Anomalies of heating rate estimates from GOES (Bob Rabin) as proxy for soil moisture

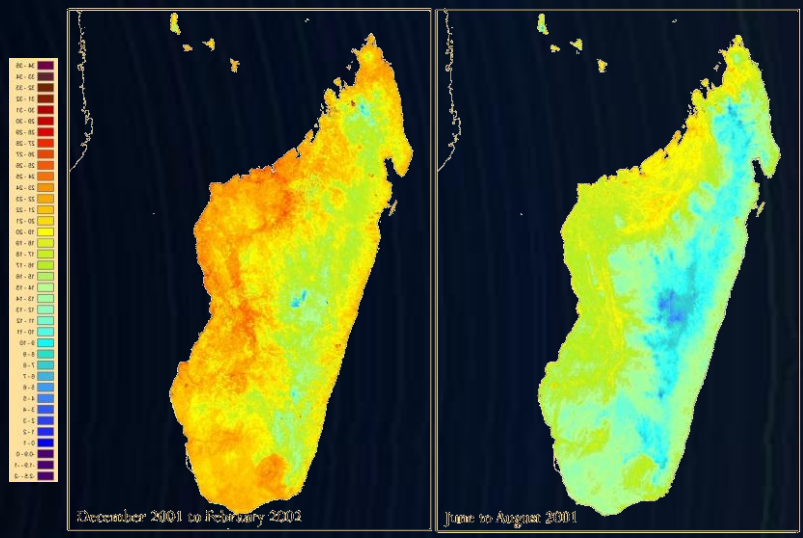
Algorithm development

Expand the risk reduction component through the development of derivative products such as air temperature which is crucial for human health and agriculture related application; an application has already been done in Africa with MODIS observation (Ceccato, Temimi et al, 2010)

Also, skin temperature from GOES-R allows for better determination of microwave emissivity

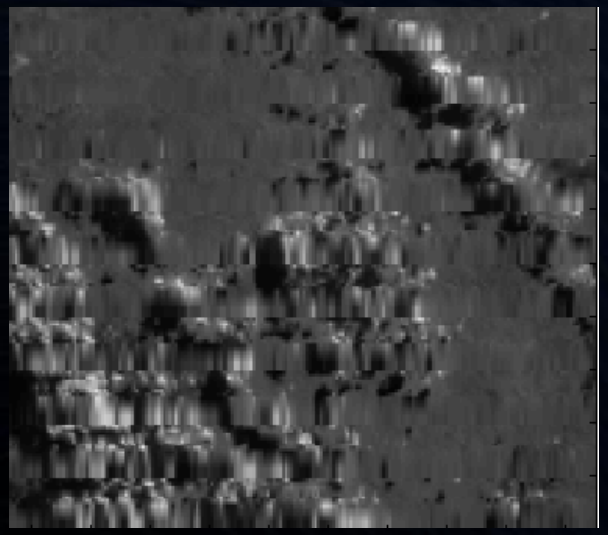
Ts estimates may also help in determining frozen ground which important for hydrological application in northern locations.

Example of Air temperature estimates

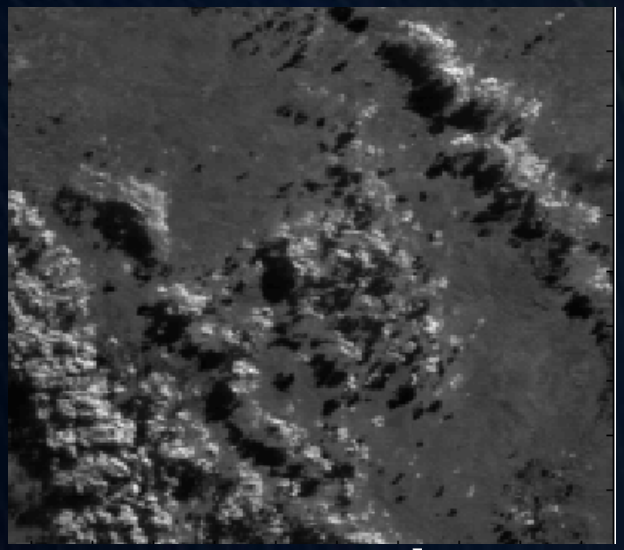


Plans for Operational Products

- We plan to use the CREST Satellite Receiving Station to produce daily restored MODIS 1.6 micron band from Aqua and Terra (validation product)



Aqua original 1.6 micron band



Restored

(**will be available from CREST in real time**)

- We also plan to create a dataset of one full snow season over the Yellowstone region that will contain a restored 1.6 micron band

Suggestions to improve GOES-R support

- Better access to the actual algorithm programs (NASA as example) making it easier to explore improvements against existing baseline performance
  - Illustrative example: Currently impossible to track down the actual cloud mask algorithms used in current GOES-GASP aerosol processing
- A Collaboration between CIMSS / CREST / NCAS to support GOES-R capabilities in addressing aerosol-cloud interaction dynamics.

This meets the 3 Cooperative Center collaborative proposal structure with expertise in

- Aerosol / cloud satellite remote sensing
- Transport of clouds / cloud lifetime
- Land based instrumentation development for validations.